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This is the second of a two-part review of instructional procedures in secondary school science. Analyzed are research studies in the field mainly over the period 1960-67. Studies were reviewed under the following headings: team teaching, programed instruction, audiovisual aids, laboratory procedures, extra classroom activities and field experiences, content integration, classroom interaction, and teaching duration. Thirteen conclusions and suggestions summarize some of the implications of the findings of the research reviewed. A bibliography listing 103 studies is included. (GR)

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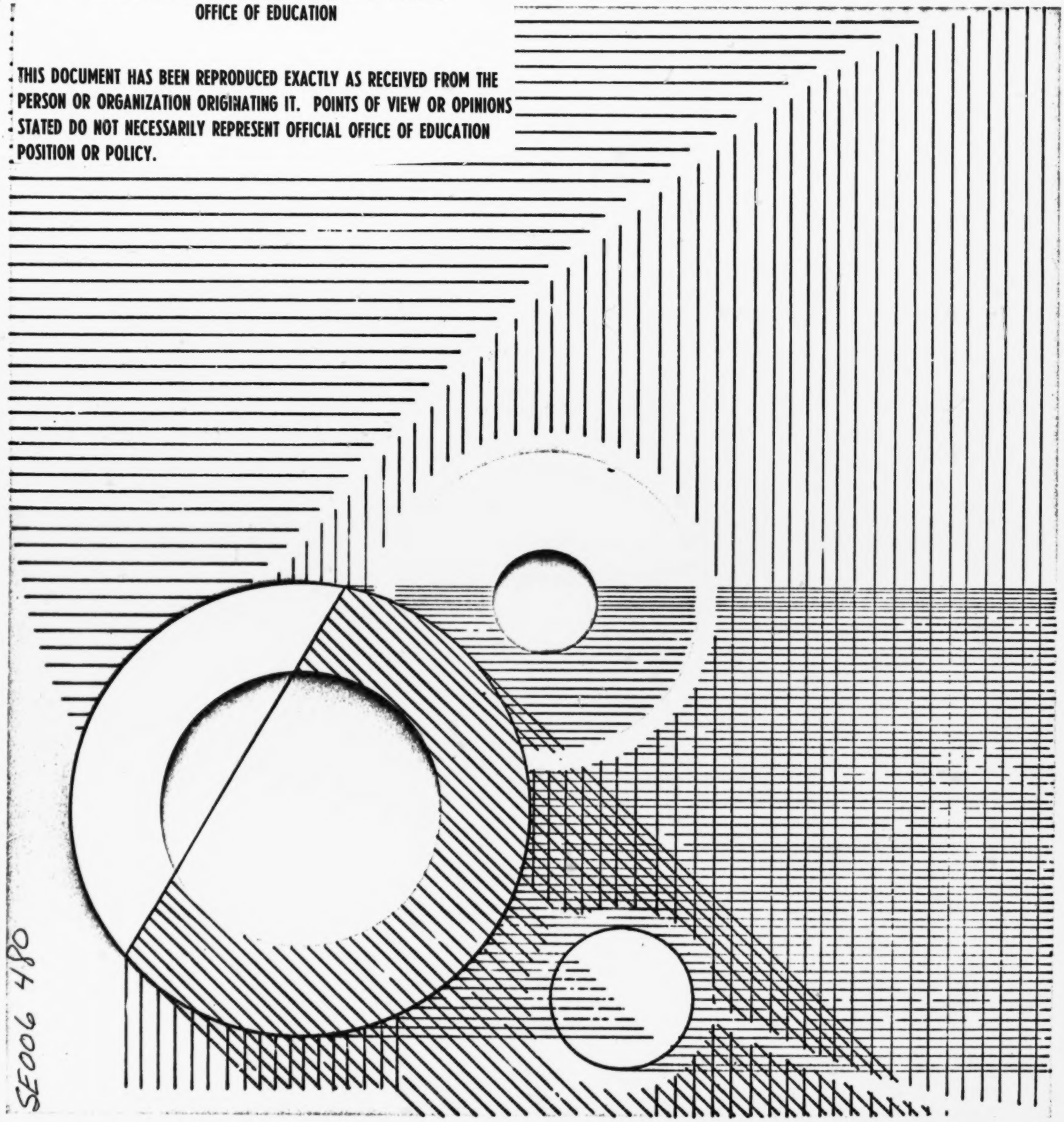

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4 LETTERS

8 NSTA ACTIVITIES

14 EDITORIAL
Milton O. Pella

15 THE SPIRIT OF SCIENCE—WORLDWIDE
Albert V. Baez

19 SCIENTISM IN SCIENCE EDUCATION
George Eastman

22 THIRD ANNUAL FUSE CONFERENCE

23 PROGRAMING THE INSECT'S LIFE CYCLE
Raymond G. Pierce

28 PHENOLOGY PROGRAM OF THE IBP
David M. Gates

32 FREEDOM AND A VARIED ENVIRONMENT
R. Thomas Tanner

35 CAN OUR CONSPICUOUS CONSUMPTION OF NATURAL RESOURCES BE CYCLIC?
Leallyn B. Clapp

38 SCIENTIFIC INSTRUMENTATION IN CRIMINAL INVESTIGATION
Alexander Joseph

53 CLASSROOM IDEAS

ACCIDENTALLY DISCOVERING AN OPEN-ENDED EXPERIMENT
Samuel C. Dickieson

53 HYPOTHESIS MACHINE
Frank Micciche and Michael Keany

55 THE ALPHABET GAME (TAG)
James Migaki

RESOURCES/REVIEWS

60 BOOK REVIEWS

62 BOOK BRIEFS

66 AUDIO-VISUAL AIDS

69 APPARATUS AND EQUIPMENT

72 AN ANALYSIS OF RESEARCH ON INSTRUCTIONAL PROCEDURES IN SECONDARY SCHOOL SCIENCE
PART II—INSTRUCTIONAL PROCEDURES
Gregor A. Ramsey and Robert W. Howe

92 THE SCIENCE TEACHER'S CALENDAR

92 INDEX OF ADVERTISERS

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An Analysis of Research on Instructional Procedures in Secondary School Science

Part II—Instructional Procedures

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THIS TWO-PART REVIEW of research related to the teaching of science focuses on instructional procedures used in the secondary schools. Part I, published in the March issue of *The Science Teacher,* included studies on the outcomes obtained from generalized instruction in a classroom or classroom-laboratory setting. Part II includes studies that identified a particular instructional procedure.

There were 11 reports on team teaching, 16 on programed instruction, 17 on audio-visual teaching, 8 on field trips and extra-classroom experience, 11 on laboratory methods, 6 on classroom interaction as a result of a particular type of instruction, and 5 used content integration.

Team Teaching or Large-Group–Small-Group Instruction

These two descriptors are used in the literature to describe essentially similar processes, and any fine differences in meaning which may be drawn do not hold up over a wide range of studies; therefore no attempt will be made to divide the group. In the context of this paper, team teaching or large-group–small-group instruction may be considered a specific administrative alternative to the usual arrangement of one teacher instructing the same class unit.

Probably the most extensive and detailed study related to the "large-group–small-group" arrangement was one undertaken by Winter, Farr, Montean, and Schmitt [98]. They studied this method for teaching Regents Chemistry in New York State. This method of instruction gave some indication of producing greater success on the Regents examination and on specially prepared content tests although little difference was detected on science-reasoning tests over students in traditional classes. Two pieces of evidence which did seem surprising were that students withdrew from large-group–small-group classes in significantly greater numbers than from conventional ones and that attendance was superior in conventional classes. Reasons for these differences were not drawn out, but the researchers believed that the large-group–small-group instruction acted against the poorer student.

Cost comparisons were difficult to make, but costs seemed about the same no matter which method was used. More important was the finding that teachers had on the average almost twice the preparation time available that teachers in traditional classes had for the same mean pupil-teacher load. Also it was felt that students became less dependent on their teachers and relied more on their own efforts in a team-teaching situation. This may in part explain why the poorer students tended to drop out of the large-group–small-group classes.

There have been several less extensive studies on team teaching. Breedlove [15], again in chemistry, found that team teaching produced satisfactory learning in students, that it gave a means of curriculum and teacher improvement, and that it could be used to supplement the education of student teachers. White [94] compared the effectiveness of team teaching with conventional class procedures and found no significant differences in achievement among three levels of intelligence compared. In other comparison studies, Hunt [40], Williams [96], and Meiller [60] found no significant achievement gains of one method over another.

Sutman and Yost [90], in a study with above-average seventh-grade science students utilized a master teacher who acted as a team leader and taught key lessons when required. The assigned teachers of science in this study were not well prepared, and it was found that students in classes organized and helped by the master teacher made significant achievement gains over control students who were in conventional classes taught by their assigned teachers without the help of the master teacher. The master-teacher method was considered to bring about some improvement in the teachers in the team situation.

Davis [24] used a questionnaire technique to find out what teachers in a team-teaching situation thought of the procedure. He found that team teaching is unlikely to work well if teachers are forced to adopt it for reasons that are not clear to them. The team approach needs continuous planning throughout the school year. It is not likely to be successful in a school not geared to accommodate it or if it works counter to the overall policies, philosophy, and administrative arrangements of the school.

Finley and Louderback [29] described the Ferris High School, Spokane, Washington, where the entire school was devoted to individualizing instruction by large-group–small-group methods. The classes could be of any desired length in terms of the 15-minute module, there were no bells, and considerable time was devoted to individual study. Here is an example of a school geared to the philosophies of a new approach, and it is one where subjective opinions rate this approach as highly successful.

There seems to be some confusion between a large-group–small-group teaching arrangement and true individualized instruction. While it can be said that the large-group–small-group arrangement may provide opportunities for individuals to learn alone or be helped on a 1 to 1 basis, the learning experiences are still highly structured and common to all students. They do not take into account basic individual differences in their formulation.

There is no evidence as yet that a team-teaching arrangement can improve student gains over those they would have achieved in a class situation with an effective teacher. Such a teacher can provide small-group experience and individual opportunity for study if he desires. A team arrangement, however, does permit a teacher's individual strengths to be shared by as many students as possible, and his weaknesses to be either camouflaged by other members of the team, or diluted by their spread over a larger number of pupils. Advantages appear to be in terms of teacher rather than pupil gains. Given the same number of teachers and pupils, the teacher can gain up to double the normal amount of free time available for preparation in a team-teaching situation. Student gains are likely to depend very much on how the teacher uses this extra time for planning or individual conferences.

Programed Instruction

Programed instruction may be looked on as a method of instruction using a sequence of carefully planned subject-matter items which are presented to the learner so as to require his active response. Cues are used to help the learner give the correct response, and these are reinforced so that the individual learner moves ahead through the program at his own pace.

Programed instruction is most often directed toward highly specific learning outcomes, and usually the only allowance in a program for individual differences is the speed at which a person proceeds through it. Attempts have been made to produce branching programs with different learning paths which may better match the learning patterns of different individuals and also to relate the instructional base to different learners' needs by covering the same content in different ways. Theofanis [91] compared two programs, one written inductively and the other deductively, covering the same content. He investigated whether there was any correlation between instructional base and student mental ability. He found that students of low and high mental ability learned better inductively, while average students showed no significant differences between the two methods.

Some distinction should be drawn between programed instruction and individualized instruction. Individualized instruction attempts to provide a complete instructional program designed explicitly for each individual, taking into account his background experience, interests, and ability. Programed instruction is individual in the sense that it is 1 to 1 instruction. It may be an important part of the individualizing process, and is particularly efficient where the transmission of specific content or a review of principles is required; however, this is only part of the total learning picture.

There have been many studies—e.g., Zesche [103], Sayles [79], Young [102], Darnowski [23], Besler [14], and Carnes [16]—to show the effectiveness of programed instruction in imparting content. Students either reach the same level of achievement in less time (Young) or a higher level of achievement in the same time (Carnes) when compared with control students taught by another method. Programs have been used as successful adjuncts to normal courses; e.g., Besler with Chemical Education Material Study (CHEM Study) or Carnes in seventh-grade science or Sayles as a supplement to teach bonding and molecular geometry in a normal chemistry course. That programed instruction has a place in the total instructional scene has been firmly established by studies such as these; however, what the place is has been almost totally neglected by researchers. Research has been largely preoccupied with the nature and effectiveness of individual programs rather than with how these may best be applied in the school situation.

Several studies (e.g., Woodruff *et al.* [101] and Sayles [79]) have pointed out that students find programed instruction fun at the beginning, but can soon tire of it when it is used to excess. This confronts the teacher with an attitude problem if the method is used as a primary instructional technique.

There is some evidence (in studies by Eshleman [25], Aaron [1], and Darnowski [23]) that control groups taught material in a conventional way retain the content more effectively over a longer period than do students taught by programed instruction methods. Many factors relating to the type of program used and the method of instruction carried out in the control group could affect

such a finding, and much more research is needed before this could be taken as a definite trend.

Nasca [66] found that programed instruction in science does not necessarily rule out individual laboratory experiences, and that such experiences can be made an integral part of such a program if they are highly structured. Other studies which investigated different ways of utilizing programs were done by Aaron [1] in biology and Woodruff *et al.* [101]. These indicated that programed-instruction sequences could be used as effectively as traditional assignments and that if they are used at home, this should be under the jurisdiction of the regular teacher so that students feel accountable to someone they respect.

Programed instruction rests firmly on a behavioral-science base for its effectiveness. Glaser [34] has outlined what this base should be for any instructional design, and much of what he says applies to programed instruction as well as other areas. He cites as important the diagnosing of preinstructional behavior and gives the preinstructional variables which determine course achievement. He also lists some conditions which influence the instructional process. Some of these are sequencing, stimulus and response factors, self-monitoring, interference, practice, and response contingencies like the correction of errors. Two studies which related to this area were those by O. R. Anderson [9] and Lindbeck [55].

Programed instruction provides an efficient method of learning in many content areas and has a definite place in science teaching. Each individual teacher and each school should make some evaluation of what this place is, and perhaps contribute to the meager literature on its effective utilization in the classroom.

Audio-Visual Aids

Teachers and administrators have long looked to audio-visual aids to fill instructional gaps in conventional teaching procedures. They have been used either to supplement normal teaching procedures or to take over completely the instructional process in the classroom. Dramatic hoped-for gains in effectiveness of instruction by either of these methods have generally not been demonstrated in practice.

The research in this area is divided into two sections: those in which the media perform the complete instructional role, and those where the media supplement the classroom procedures of the teacher.

The Complete Instructional Role

The sciences which seem to have used films as a complete instructional procedure have been physics and chemistry. This is understandable in that it is probably in these areas that the lack of well-qualified teachers is most keenly felt. The argument goes that if we cannot find a good, well-prepared teacher in the flesh, then one on film or television may be almost as effective in the classroom. Evidence for this, however, is lacking.

The two filmed courses of instruction which have had the most attention in this regard have been the Harvey White Physics Films [1] and the John Baxter Chemistry films.[2] Each of these series consists of more than 160 films, each of 30-minute duration, which were intended to perform the major instructional role in the classroom. There have been several studies regarding their effectiveness. These showed that they produce little in the way of achievement gains over traditional procedures.

Some of the studies in which these comparative evaluations were attempted include the 1959 Wisconsin Physics Film Evaluation Project,[3] an investigation in Utah high schools by Noall and Winget [69], the University of Kansas study by K. E. Anderson and Montgomery [7], a comprehensive Kansas study by Popham and Sadnavitch [76], and a Texas study by Jackson [42].

In general the findings indicated that the chemistry films proved as effective as conventional methods on achievement; however, the physics films were not as effective as conventional methods for promoting learning. No significant correlations could be detected between instructional method and intelligence, nor did either form of instruction favor one ability group over another. The films seemed to promote more unfavorable attitudes toward the subject than did the conventional methods, and they did not foster any increased interest in physical sciences.

An interesting study reported by Scott [83] as a part of the Wisconsin Film Evaluation Project, consisted of a summary of the responses to questionnaires sent to teachers and students in 30 schools taught by film or by conventional methods. Some of the findings included:

1. Films could effectively replace traditional laboratory demonstrations.
2. Films have the greatest contribution to make in schools where the laboratory facilities are limited and teachers are poorly prepared.
3. Students do not like studying physics by film as well as they do by traditional methods.
4. The films present matter too rapidly, they lack flexibility, and do not help maintain interest in science as well as do traditional methods.
5. Teachers learned many helpful procedures but did not in general like giving up their instructional role to another teacher. Two-thirds of the teachers and students expressed negative attitudes toward the films.

These studies create some doubts regarding the teaching of science courses completely by film. The Scott study points to what could be the major instructional role of films, that of providing the teachers with new ideas for presentation, demonstration techniques, and other procedures they may use with effect in their classes. This has indeed become the trend in some of the newer course improvement projects.

Media As a Supplement

It seems unlikely that filmed courses can take over the complete instructional role, and a more promising line of research is to look for effective ways of using audio-visual aids to supplement what the teacher is trying to do in the

[1] A course on television—film developed from a course taught by Professor Harvey White, University of California, Berkeley.

[2] The Professor John Baxter Chemistry Films, financed by the fund for the Advancement of Education and distributed by Encyclopaedia Britannica Films, Incorporated.

[3] The Wisconsin Film Evaluation Project: University of Wisconsin, Madison. 1959.

classroom. Often, films and television have been used quite passively. The students have watched, there may be some discussion at the end, but no real attempt is made to make the film an integral part of the lesson procedure.

Smith and Anderson [87], Jacobs and Bollenbacher [43], and Nasca [68] in their studies looked at ways of presenting audio-visual experiences as part of class instruction. These studies indicated that the impact of films is bolstered if principles are stressed by the teacher, that class discussion of the audio-visual experience definitely enhances achievement, and that too much audio-visual instruction hampers the more able student who seems to need experiences with other science activities more than does the less able.

One study which points hopefully to a future trend is one by Poorman [75]. He used Harvard Project Physics as the content vehicle to compare the effectiveness of a multi-media systems approach with a traditional approach to teaching. The multi-media approach seemed to favor high and low achievers and increased student interest in studying physics. More studies of this kind are needed if the many instructional media now available are to be satisfactorily integrated into the classroom situation.

For the effective design of audio-visual experiences, whether by film or television, it is important to know how these aids provide learning experiences for students. Studies which investigated different methods of conveying information by film or television include those by Clegg [19], Schulman [82], and Nasca [68]. These studies indicated that facts transmitted by inference were retained best; that the nature of the film introduction, whether positive or negative, affected retention; and that forced attention by requiring the students to make verbal or written responses, complete diagrams, or work programed sequences improved retention.

Wickline [95] was concerned with the development of attitudes via the movie film medium. He used the "Horizons of Science" film sequence with his experimental group but found no significant change in attitudes toward science or scientists, although there was improvement in understanding science. There are weaknesses in this study—it was small, the films were not designed specifically to change attitudes, the tests may not have been discriminating enough; however, it was a start in an important area.

Two studies incorporated audio-visual aids into a programed instruction sequence for teaching some aspect of science. A particularly interesting study was one by Schrag and Holland [81] who used a Physical Science Study Committee (PSSC) film as part of a programed course of instruction to teach "Frames of Reference." The student begins the program by pressing a button which starts the projector, and after the filmed sequence is presented, the projector cuts off. The student then knows to go on with the next printed frame. The machine can bypass unwanted film material by moving on without the light and sound track in operation. It seemed that in the integration of the film and the printed items, several different relationships occurred between film and print—relationships which could not appear if one or the other were used alone. Students who used the programed film technique scored higher on tests than did students who went through the PSSC material on "Frames of Reference" and viewed the film separately.

One criticism of any programed instruction technique in science has been that it usually does not allow learning by direct experience. Laboratory experiences are often excluded. A study to test the validity of this criticism was one by Gordon [35] who compared: direct laboratory experiences, silent motion picture demonstrations, still picture, and symbolic forms to present experiments to seventh-grade junior high school students. He found no significant differences between the four groups.

Gentry [31] investigated the relative effectiveness of teaching concepts through the single-concept loop. He used ordered and random-concept sequences taught by expository and discovery narration. While the differences were not statistically significant, a trend favored discovery narration for less-able students and expository for the more able. Gibbs [32] in another study in this area found that the ability to construct relevant hypotheses in Biological Sciences Curriculum Study (BSCS) biology was improved significantly in classes using the loops.

More research is needed to determine the most effective ways of instructing with the loops, and also the most effective ways of programing the frame sequences within each loop. It seems highly likely that no single concept loop can serve all learners equally well.

Audio-visual aids are valuable supplements in the instructional process, but like any other instructional procedure, they need thorough evaluation before generalizations are made. They have been shown to produce measurable student gains if they are used as an integral part of the instructional procedure. They fail in the usual classroom setting if the students are just passive watchers or if the instructional initiative and responsibility is taken away from a competent teacher. Effective integration of audio-visual aids into the instructional sequence is likely to make the teacher's job more difficult rather than easier, and what is needed now is concentrated research on how to best bring about this integration.

Laboratory Procedures

That the experiences possible for students in a laboratory situation should be an integral part of any science course has come to have wide acceptance in our science teaching. What the best kinds of experiences are, however, and how these may be blended with more formal classwork, has not been objectively evaluated to the extent that clear direction based on research is available to the teacher.

There have been many suggestions and descriptions of laboratory approaches found subjectively successful in the classroom. Many of these have been described over the years in various journals and have no doubt proved a useful source of laboratory ideas for many teachers. These suggestions may be classified under the heading of "teacher tips." They have been found useful by their proponents in the teaching situation, but they may or may not have wide applicability and have not been subjected to the close scrutiny of educational research. Several examples of descriptions of this kind are listed in the bibliography; e.g., Alyea [4], Meyer [61], Esler [26], Grant [36], Pad-

dock [72], Hummer [39], Lanni [51], Witters [99], and Amend [5].

The purpose of a study by Jeffrey [44] was to define objectives of the chemistry laboratory. He classified outcomes in terms of six major competencies and devised tests to measure the achievement of students in each of the areas. The competencies expected were (1) Communicative—can the student identify laboratory equipment and operations? (2) Observational—can the student record observations or observe errors in technique? (3) Investigative—can the student record measurable properties of an unknown substance? (4) Reporting—can the student maintain a laboratory record? (5) Manipulative—can students manipulate laboratory equipment? and (6) Demonstration of laboratory discipline—can the student observe safe practice and maintain an orderly laboratory? To test the first three competencies, a set of slides and movie film were prepared, while no tests were proposed for the last three. This study does give direction for some form of effective evaluation of the outcomes of student laboratory experiences but much more work in this area is needed if the laboratory experiences are to be directed toward predetermined measurable learning outcomes.

There has been some move in science teaching to provide laboratory experiences which are "open-ended." Studies by Charen [17], Rainey [77], Mark [57], Marin [56], and Lennek [53] lend support to this trend. In general, gains in outcomes like knowledge of facts and principles, recall of experimental specifics or ability to interpret knowledge showed no significant differences or favored the open-ended method. These studies support the position that students can take a more active part in formulating their experimental procedures without suffering any major consequences in terms of achievement.

The laboratory situation is often one of group dynamics. What is the best method of grouping students in a laboratory situation? What kinds of interactions occur, and how do these affect the work output of any given group? Hurd and Rowe [41] analyzed small-group dynamics and productivity in a BSCS laboratory block program where students typically work in groups of four every day for approximately six weeks. Tests and teacher observations were used to preassign groups as compatible and noncompatible. It was expected that there would be a high correlation between group compatibility and test score; however, in some cases the more incompatible the group, the higher the mean score. Observation showed that incompatible groups resolved their difficulties differently. Some groups reduced tension by increased task activity (these tended to be noncollege-bound students) while other groups reduced tension by temporarily leaving the group or by engaging in more negative behavior, with a corresponding decline in activity (these tended to be college-bound students.) This fascinating study opens a side field to research. There may be several explanations for the findings, and they do shake many of our preconceived notions regarding group interaction in the laboratory. The full import of group dynamics to laboratory instruction can only emerge with further detailed studies of this kind.

It has become almost self-evident that one of the aims of science teaching is to develop problem-solving skills and that the laboratory is the place where the student may be introduced to the experimental method for solving problems. Yet very few studies in the literature describe attempts to analyze the processes of problem solving by high school students. O'Connor [70] and Chess [18] attempted to do this in their studies. Some of the findings of interest to teachers include: The person must feel an identification with the problem. Similar words convey different meanings with different individuals, and the same word may change meaning with the same individual over the period the problem is being solved. Some degree of mind-set characteristically followed formulation of an hypothesis. Also, no common problem-solving pattern could be established, and successful problem solvers were not restricted to any particular ability group.

It has been suggested, and indeed it is the trend in many of the course improvement projects, to make laboratory experiences central to instructional procedures in science. Yet direct research on what these experiences should be, how they should be organized, and where they function best, is indeed meager.

There is evidence to suggest that it is worth increasing the number of "open-ended" experiments used in class. Laboratory experiences should be designed as problem-solving experiences, and should be directed to specified learning outcomes. More research is needed on how students solve problems both individually and in groups so that more efficient instructional procedures can be designed.

Extra-Classroom Activities and Field Experiences

Science teachers have long been dedicated to the principle of providing science experiences which extend beyond the confines of the school building. This has been particularly true in biology, the earth sciences, and general science where the field trip often becomes part of the tradition of the course. Yet the objective evaluation of such activities has received little attention by researchers, and it seems that field trips and excursions are continued on the basis of warm subjective feelings.

Bennett [12, 13] conducted two studies to investigate field experiences. The first compared an experimental field method for teaching seventh-grade science with a conventional method at two high schools in Florida. The second continued the refinement of his evaluation technique using his experimental field method in the saltwater environs along the Texas coast. Content for the experiments was ecological, intended to develop concepts like habitats, communities, and food relationships. There was no clear-cut evidence in favor of the experimental-field method over the conventional-classroom approach on the tests used. This points to the difficulty of evaluating exactly what the outcomes of a field experience are.

Gilbert [33] evaluated the natural science museum as a teaching resource for biology. She compared students who visited the museum and students who studied the same material without the visit. No differences were detected on the *Nelson Biology Test*, but significant differences favoring the students who attended the museum program were obtained on an investigator-prepared test.

Wong [100] describes a "great ideas" approach to

biology where students carry out their own research programs. The students call on local scientific institutions and have a valuable consultative service of local scientists. Evaluation of such a program, Wong suggests, should be in terms of the quality of the research material produced.

Lamie [50] reports a course in oceanography taught to 24 high school students in New York State, part of which was taught on an oceanographic cruise. The students were able to collect deep-sea living organisms, larvae found in deep-sea plankton, and to study phosphate and nitrate concentrations at different depths. Instructors for the course were oceanographers of the Lamont Geological Observatory. They provided equipment, specimens, films, slides, and the like. A course in oceanography was developed from this instruction.

Typical innovative field experiences are described by Shoemaker [84], Mohler [62], and others; however, these are descriptions of methods found to work by enthusiastic teachers rather than approaches of general applicability. If one poses the question "If we had no field trips, what would we lose?" the answer based on evaluation with major tests would be "very little," but based on teacher-developed instruments and subjective opinion, the answer would be "a great deal."

The extent to which we can and should take students out of the classroom to learn science is an area in which few guidelines are offered. The kinds of field experiences to be provided vary from teacher to teacher, and there is little evidence to help teachers decide what role they should play or what kinds of experiences they should provide. Too often the experience evolves as "We have to have a field trip again this year. What shall we do?" Such excursions are likely to have limited educational effect. If, on the other hand, the teacher decides that he cannot teach a certain aspect of his course without going outside his classroom, then he is likely to produce educational gains in the desired directions. Unfortunately, there is little evidence concerning which aspects of science can only be taught in a field situation and which science outcomes are best gained in the field.

Content Interaction

Several studies were identified which attempted some integration of content in ways which may be considered unconventional or unusual. The Iowa Science and Culture study reported by Cossman and Fitch [22] is one such integration. The course was developed by a partnership between science and social studies educators, both in the initial planning phase and the teaching phase in the classroom. History of science as an intellectual development of ideas, rather than chronology of facts was the vehicle for this course. Significant gains in favor of the "Science and Culture" course students were found over matched control students in understanding the scientific process, in understanding scientists as an occupational group, in critical thinking ability, and in understanding the character of scientific and nonscientific segments within cultures and the evidence for interaction between them. These results are extremely encouraging, and hopefully further courses along these lines will be developed in other places. This study on junior and senior students is now being extended from its trial in a university school setting to the Cedar Rapids, Iowa, public schools.

Clewell [20] integrated intermediate algebra and chemistry. He found no significant differences in achievement between the groups who had the integrated course and those who received these courses separately. Where the integration is likely to enhance understanding of both (this is not obvious in the Clewell study) one can expect gains in the integrated situation. This was indicated in a study by Starling [89] who integrated biological principles with a course in vocational agriculture.

A study by Johnson [45] lends support to this notion of mutual enhancement. He found that the integration of physics and chemistry produced achievement and understanding of chemistry and physics concepts (in CHEMS and PSSC) superior to that from these courses taught separately.

Amend [3] was concerned with developing a series of "laboratory blocks" which cut across and integrated traditional subject areas of physical science. These were designed for senior students and could be used either for independent study or class use. The laboratory blocks developed—Instrumentation for the Detection of Visible Radiation, Nuclear Structure and Isotope Identification, Spectroscopy and Color, and Electro-chemistry—had some preliminary evaluation. However, it is not the evaluation so much as the suggestion for new ways of integrating content into a viable instructional sequence which may be useful to teachers.

Very little has been reported on content integration of science with subjects outside the science field. The positive findings of the Iowa Science and Culture study suggest that science can be effectively integrated into a social studies context, while the integration of two subjects which are mutually enhancing seems to produce a symbiosis of benefit to both. It is not the intention of this paper to go into "unified science" *per se*, as this is a curriculum development rather than an instructional procedure; however, the reader's attention is drawn to the dissertation by Siesnick [86] and the report by Richardson and Showalter [78] where a completely unified science program is compared with the traditional separate subject approach in the high school. The findings indicated that course content and method organized upon a superstructure of "big ideas" of science unrestricted by separate subject boundaries provides a viable alternative to traditional procedures and allows students to form a more inclusive rational image of the universe than do control students taking separate sciences over a four-year period.

Classroom Interaction

Interaction between teacher and student, whether on an individual basis, or between small groups and the teacher, or between the class as a unit and the teacher, depends very much on the instructional procedures being used. An increasing number of studies are being directed to the documentation of such interaction in various teaching situations.

Three studies were identified which investigated teacher-pupil interaction in high school biology classes. Parakh [74] used an audio tape recorder to pick up verbal com-

munication between teacher and students, while studies by Bulour [11] and Evans [27] used a video recorder to record both verbal and nonverbal behaviors of the teacher. Parakh found that in lecture classes, the percentages of total time devoted to teacher talk, teacher's pedagogically relevant nonverbal behavior, and pupil talk were 75, 10, and 15 percent, respectively, while in the laboratory these percentages were 50, 40, and 10. Also, he found that explicit statements about the nature and processes of science occurred infrequently, less than 0.5 percent of the total time in lectures and laboratories. The Bulour and Evans studies found that teachers spent the majority of their time in the area of content development and management, and only about 6 percent of their time outside these areas. Most teacher behaviors were teacher-centered, and the largest percentage of teacher time was spent giving and receiving information at low cognitive levels.

Schiever [80] investigated the effect on classroom discussion of teachers' responses to student queries and statements. He found that the proportion of positive responses by teachers is much higher than that of negative responses (only about 7 percent negative). However, the positive or negative response led to teacher rather than pupil action in more than 90 percent of the cases. It seems that the positive response is used to reinforce the student. However, rather than leading to more student participation in the discussion, the effect is the opposite; it seems to turn the student off and the teacher on.

Three studies in physics investigated the kind of interaction occurring in physics classes. Snider [86] and Punkrus [73] used the Flanders verbal interaction analysis scheme while Matthews [58] used a video recorder to obtain a permanent record of the teaching situation which could be analyzed later for both verbal and nonverbal behaviors. The Snider study gave evidence that physics teachers rarely employed social skills connected with aspects of positive motivation, rarely built on student ideas, and rarely utilized "discovery" techniques in the classroom; however, they did tend to ask more thought-provoking questions than did junior high school teachers. Matthews in his study, revised a partially developed category system and modified it to construct a set of categories for describing instruction used in the classroom by PSSC and non-PSSC teachers. This instrument has considerable descriptive power and pointed to the large amount of time teachers in both groups spent on presenting content verbally.

Pankratz took a different approach. He selected two groups of teachers, those ranked high and those ranked low by the principal and students according to teacher-ability criteria. The Flanders system was used to analyze classroom behavior, and significant differences between the groups were attained. Teachers in the "high" sample used more praise and reward, more cognitive and skill clarification, used fewer requests and commands, less criticism and rejection, and experienced less confusion. Such teachers used student ideas more effectively and seemed to ask different kinds of questions. Both groups spent about half their time giving instruction via lecture, which agrees closely with the proportions found in the Matthews study. These studies were in the main descriptive. They were concerned with developing instruments which would give a more definitive picture of what is going on in different classrooms by analyzing the behaviors and interactions occurring therein.

Teaching Duration

Two studies were identified which attempted to relate pupil achievement to duration of teaching. In one, Olstad [71] investigated the effect of length of class period on biology achievement in three randomly assigned groups of students. Two groups met on alternate days for two-hour periods of time while a third group met daily for a single-hour period. One of the two double-period groups capitalized on their time allotment, while the second group treated it as if it were simply two single periods placed together. The two-hour method, when utilized to the full, produced a significantly greater attainment of problem-solving skills and was more effective in increasing variability in student achievement. Students in this class arrangement also seemed to react more positively to their biology instruction.

In the second, Welch and Bridgham [93] investigated the pacing of instruction, and whether student achievement bore any relation to the length of any time spent on a particular unit. No significant correlation was found between achievement gain and elapsed time. The second hypothesis was that teachers would spend a longer time teaching slower students. This, however, was not shown to be so, and the number of days spent teaching a unit was not a function of average student ability.

It does seem that longer class periods may allow teachers to do things in the classroom not possible in a normal-length lesson. What these things are and how a longer class period may best be utilized needs further investigation. The Welch study points to interesting avenues for research. What are the factors which determine how long a teacher spends on a unit? Is this time related to student characteristics, and if so, which ones? It certainly seems that it is not related to student ability. Is this time related to teacher characteristics, and if so, which ones? Do outcomes other than achievement require more time to develop? Although there is very little correlation between achievement and teaching duration, correlation may exist between other outcomes; e.g., attitudes and teaching duration.

Conclusions

The following conclusions and suggestions are offered to summarize some of the implications of the findings of the research reviewed.

1. A common terminology must be established so that instructional procedures used in one study may be readily replicated or compared with those used in another.
2. More sensitive evaluative instruments are needed to measure the outcomes of instructional sequences. This is particularly true in the areas of laboratory instruction and field experiences.
3. Studies reviewed here showed team teaching to be an administrative device which gives teachers more

preparation time without having any marked effect on student outcomes. Any significant improvement in student outcomes over those obtained in traditional classes is likely to depend very much on how effectively teachers use the extra time available.

4. Programed instruction provides an efficient method for learning specific content outcomes, but its actual place in the total instructional picture is not completely clear.
5. Audio-visual media, films, and television should not be used to take over completely the instructional role in the classroom, but should be integrated carefully into the instructional pattern.
6. The greater the student activity and participation with the audio-visual media used, the greater the gains in student outcomes.
7. Problem solving for students is an individual experience, so such experiences should be individualized to meet the needs of each student. To do this, more information is needed about the way individuals solve problems both alone and in small groups.
8. Field experiences are only likely to be successful in producing significant learning gains if the outcomes required cannot be taught effectively and efficiently in another way. Little is known about what outcomes may be expected from field experiences.
9. Integration of different content areas is effective in terms of improved student outcomes provided the reasons for the integration are clear, and the instruction is consciously directed toward the required outcomes. This seems true whether the integration is brought about by one teacher teaching an integrated course outline or the outline is taught by a team of two or more teachers.
10. Increasing emphasis is being placed on finding out the actual classroom behaviors of teachers and pupils, and more sensitive instruments are being developed for this description. Attention can now be directed to the nature of interactions between students and the teacher in different instructional situations to determine the effectiveness of instruction.
11. Changing the length of a lesson permits teachers to innovate in ways not possible in a lesson of standard length. These innovations seem to increase desirable outcomes.
12. The length of time a teacher spends teaching a given content unit has surprisingly little effect on the achievement of content outcomes of the students. Whether it affects other outcomes is not known, nor are the factors known which determine how long a teacher spends teaching a particular unit.
13. Ways must be found to strike a balance between competing instructional media in the classroom so that each is used where it can produce the desired outcomes most effectively.

Research in instructional procedures has made progress. No landmark studies in the accepted sense have been identified, yet many good studies have raised significant questions. Too much of the research reviewed was for a doctoral requirement and few follow-up studies of this earlier work were seen. The problems and unanswered questions associated with instructional procedures, however, are becoming increasingly clearly defined. This should lead to significant research and the promise of more progress in the field.

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